Investigation of Stem Photosynthesis by tracing internal 11-C labelled CO_2 in plants

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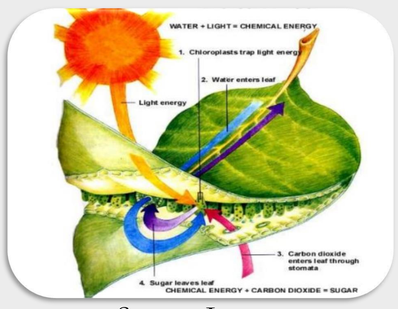
Motivation

- The impending effect of climate change on the trees and how they cope with it has always been an interesting field of research
- Tracking down the internal CO_2 transport in the xylem might give a potential clue of how the trees accustom themselves during drought or external stress conditions

Source: Internet

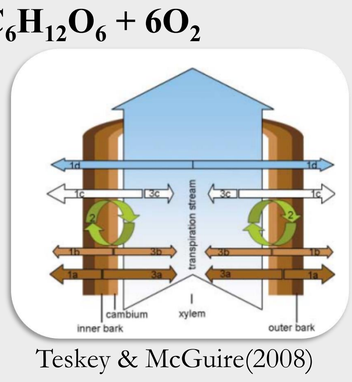
Introduction

Photosynthetic equation: $6H_2O + 6CO_2 \leftrightarrow C_6H_{12}O_6 + 6O_2$



Source: Internet

- CO_2 can be fixed by the leaves or the woody tissues in the stem and can perform photosynthesis



Teskey & McGuire(2008)

OBJECTIVES

- Study the role of CO_2 transport in the xylem of plants
- Understand to what extent CO_2 in the xylem contributes to photosynthesis
- Analyse the response of the plants during drought conditions

Materials/Methods

PET Imaging is used in this study

- Can be exploited in studying the metabolism in the plants
- 11-C is a radioactive tracer with a short half-life (20,4 min)
- Non-destructive measurements possible, [11C]-CO_2 can be used to study the metabolism in trees
- Performed on poplar (*Populus tremula*) and tomato (*Solanum lycopersicum*) branches

The steps involved while imaging the cut branches of tomato and poplar.

Branch is cut from the plant. → **Introduced into the small animal PET scanner.** → **Introduction of [11]-CO_2 radiotracer.** → **Visualization using PET (scanning 1,5 hours)** → **Auto-radiography** → **Image Processing**

Inducing the stress conditions to monitor response

Experiments are performed with PET at different stress conditions

Influence of light(using Al/Grease)
Airborne CO_2 concentration
Water availability
Relative Humidity

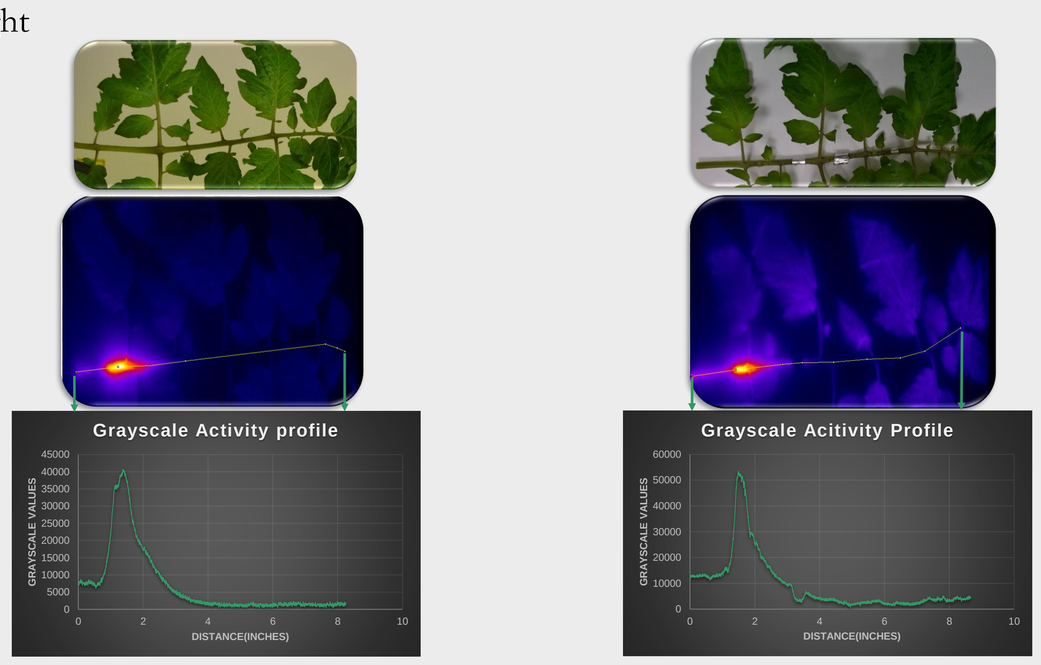
Cut branch in radioactive solution is introduced into the PET scanner and the parameters are monitored

Observation

- The autoradiographic images are processed with ImageJ software
- Airborne CO_2 concentration is also varied in these experiments

1) Influence of Light

- Use of Al/grease at specific regions over the length to obstruct penetration of light

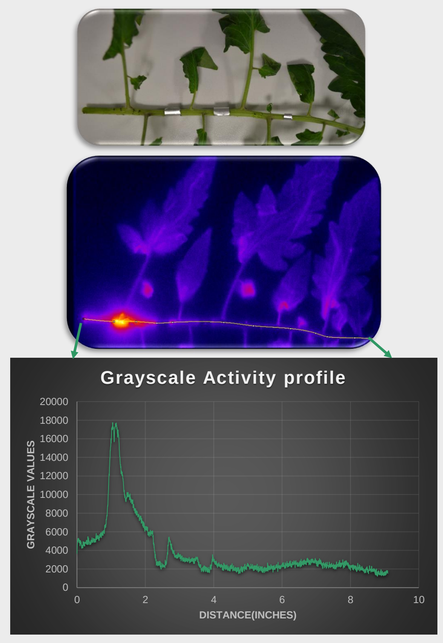


With(Right) and without(Left) light obstruction

➢ A graph of gray scale profile of the activity over length of branch was plotted. Clear dips in the profile can be observed in the regions of light obstruction.

2) Influence of Light + Water stress

- Use of membrane to exclude osmoticum from entering the xylem cells and cause obstruction



➢ Clear dips in the gray scale profile activity can be observed in the regions of light obstruction. Apparent withering of the leaves is also observed after the experiment

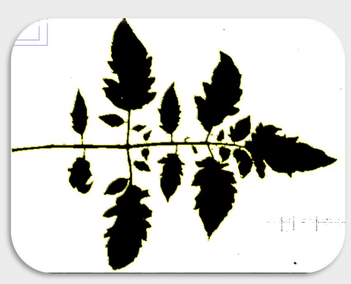
3) Calculation of Transpiration rate

- Transpiration is the evaporation of the water from the plants and it depends on several factors such as light, CO_2, water availability and Relative Humidity.
- Transpiration rate can be calculated from the following formula

$$Transpiration\ rate = \frac{1}{leaf\ area} F_{in} * (\Delta\rho)\ \text{(mol/ s)}$$

where

- Leaf area is the segmented leaf area obtained from ImageJ software (m^2)
- F_{in} is the air inflow (mol air/ s)
- $\Delta\rho$ is H_2O_{inAvg}- H_2O_{outAvg} (m mol/ mol air)



Segmentation of leaves after thresholding to calculate leaf area

Future work

- Process all the images with Image J software and apply correction factors for activity and time
- Calculation of transpiration rate for each experiment performed and compilation of results
- Image processing on the PET images: Compartmental model for further analysis

References

- wn.com/geologicallydynamic
- slideshare.net/sbishop2/b23-photosynthesis
- Teskey RO, Saveyn A, Steppe K, McGuire MA (2008) Origin, fate and significance of CO2 in tree stems New Phytologist 177, 17-32.

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